

Investigation of the Oceanic Contribution to the Earth's Axial Angular Momentum Budget

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On time scales of a few years or less, the solid Earth (mantle), atmosphere and oceans form a closed dynamical system, conserving angular momentum apart from known tidal torques. In particular, previous studies have shown that changes in the axial component of atmospheric angular momentum (AAM) can account for variations in the rotation rate of the solid Earth (measured as minute fluctuations in the length-of-day (LOD)) on seasonal time scales to within measurement error. While the lack of a significant time delay between LOD and AAM variations shows that the ocean rapidly transmits atmospheric torques to the solid Earth, the sparsity of oceanic observations has rendered more difficult the direct confirmation of an active oceanic role in the Earth's angular momentum budget.

In this study, we use a fully nonlinear 3-dimensional primitive equation ocean general circulation model, based on the Modular Ocean Model developed at NOAA GFDL, to assess both relative oceanic angular momentum (OAM) variations due to zonal currents, and planetary OAM variations due to meridional mass redistribution. The model is first spun up with climatological forcing for a period of ten years, and is then forced with NMC surface winds for the period 1992-1994. Because the ocean model conserves volume, not mass, an appropriate scaling was applied to the latter term; in addition, the effects of the rigid lid on both the current and mass terms were accounted for using the hydrostatic approximation. Once these adjustments were made, a significant correlation was obtained between the LOD-AAM residual and the OAM calculated from the model. Comparisons will also be made with the OAM budget from an independent ocean model with an isopycnal formulation. In addition to demonstrating an active role for the oceans in the Earth's axial angular momentum balance, the correspondence obtained in these studies with independent geodetic and atmospheric angular momentum determinations increases our confidence in the realism of the oceanic models.